BUILDING IN ALASKA

A Guide For Assessing Risks and Costs of Water Well Drilling in The Fairbanks Area

Developed from original work by
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This publication will help property owners in the Ester Dome, Chena Ridge, Murphy Dome, Farmer's Loop, Goldstream Valley, Gilmore Dome, Steele Creek Road and closely adjacent areas to Fairbanks, Alaska. Most of the benefits from the publication come by referencing information on maps. Instructions on how to use and interpret the maps constitute the bulk of the publication. The areas covered are shown on Map 1. The information allows the property owner or developer to assess the factors of risk associated with drilling a water well within these areas.

The elements of risk are the well depth for an acceptable yield, and the drilling cost. The target water yield of most drillers in this area to sustain a domestic household is between 5 and 8 gallons per minute. An estimate of 10 gallons per minute is used in this study to decrease risk. Additionally, the risk of obtaining water with an unacceptable level of arsenic is assessed.

ACKNOWLEDGMENTS

INTRODUCTION

In the hills surrounding Fairbanks most property owners have two options for obtaining water. They can drill a well or install a holding tank. Each method has unique costs and benefits. The decision is made more difficult by the wide variations in well depth, concentration of arsenic in the water and potential water yield.

While it is not difficult to estimate the costs of hauling water or installing and filling a holding tank, the cost of a well can vary widely depending on its location. Most often, homebuilders have estimated the likely depth of their well and the likely water quality by assuming they would be similar to neighboring wells. This method has led to many disappointments.

The information here draws on estimates of the likely well depth, arsenic concentration and well yield using all data available on wells in the area surrounding Fairbanks. The amount and the quality of the data allow an estimate of the expected depth, arsenic concentration and yield. The accuracy of these estimates is also measured.

The cost of obtaining water from a well and from a holding tank are also compared. These costs use estimates of well depth, water quality and yield. Comparing costs can help property owners decide which method to use.

There are important factors not taken into account here. These include: the availability of financing for a home that uses a holding tank; the resale value of the home; an individual's ability to pay the high initial costs of a well; the presence of other substances, such as nitrates; and, individual preference.

• Geographic Area
The geographic area studied lies generally to the north and west of the city of Fairbanks in central Alaska. This is generally the area where water is not available from the municipal utilities system. See Map 1. The 500-foot elevation contour approximates the southern boundary. The east, west and north boundaries are delineated by the Range 1 east, Range 2 west and Township 1 north boundaries, respectively. The southern boundary also approximates the division between wells that predominantly service unconsolidated deposits of the Tanana flood plain at lower elevation from wells that tap the bedrock aquifer. Map 1 shows the arterial road system of the study area and helps delineate locations in the area of interest. Note that the map scale is 1:107,980.

• Disclaimer
As in all statistical determinations, no guarantee can be made for the infallibility of this information. The ultimate risk and decision to drill or not to drill a well rests with the property owner. This information consists of what is known about existing aquifers in the Fairbanks area, as of January 1998, in order to assist in a decision before actual drilling begins. A choice can be made between drilling a well (with costs that can be estimated from the information in this publication), or installing a holding tank and having water delivered for a cost per gallon that continues over time. Details of this cost comparison are given in the section describing economic risks and tradeoffs. Costs have been updated to 1998 prices.
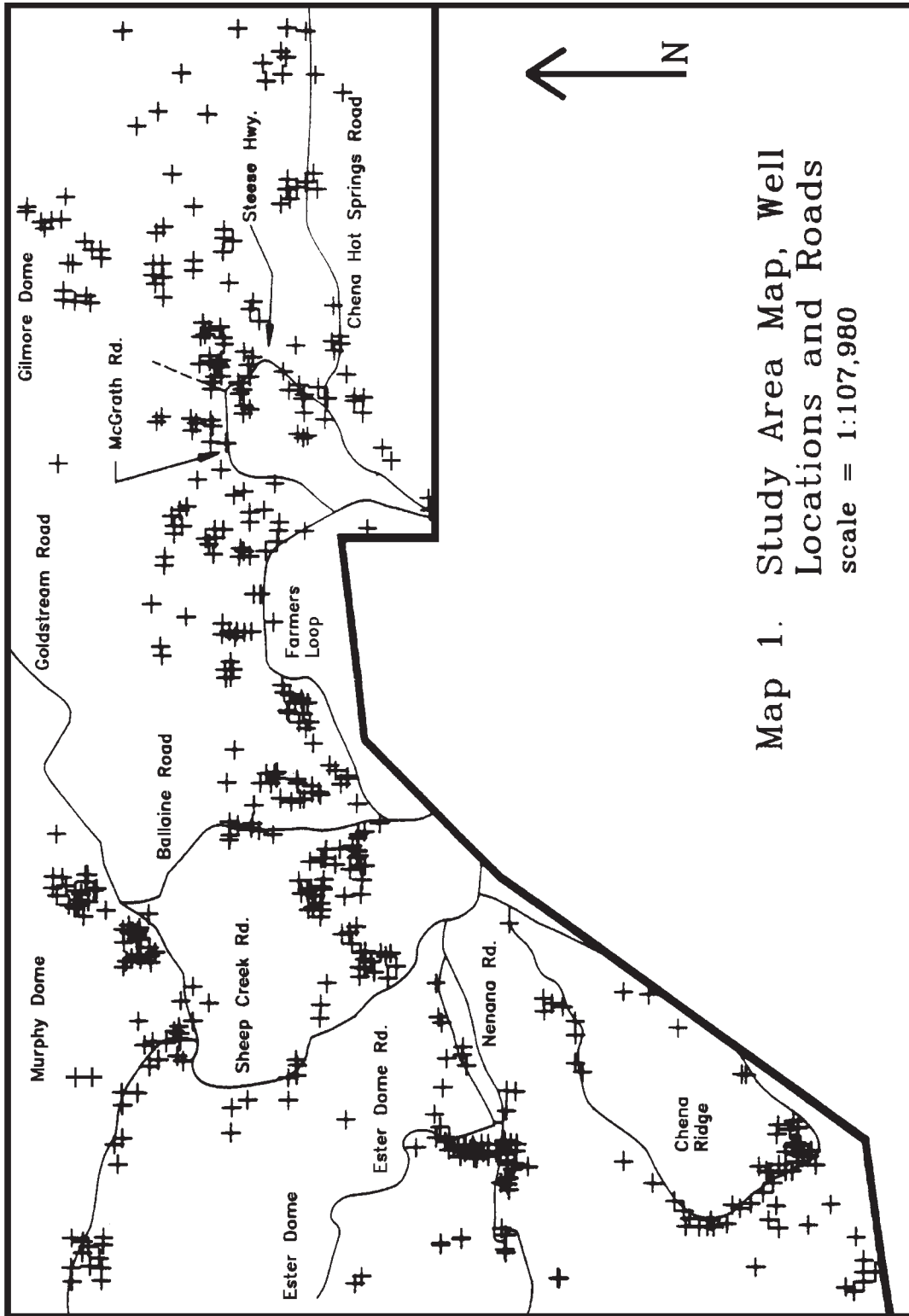
HOLDING TANKS

Many homes in the Fairbanks area use holding tanks as a source of water. Tanks of up to several thousand gallons are filled as needed by any of several water companies in the area at a cost of 5 or 6 cents per gallon. The attractions of this method are its low initial cost compared with a well, and the certainty of the water quality that will be obtained. Drawbacks are the high cost of buying water and the chance that a house loan will be difficult to obtain due to rules regarding conventional home design.

The costs of installing a holding tank and paying for water delivery are essentially the same throughout the area.

There are many alternative designs and sizes of holding tanks. Size can vary from a few hundred to several thousand gallons. Material options can change the cost of a tank. In this report, the cost of a holding tank is similar to that recommended in *Suggestions for Installing Domestic Water Storage Tanks*, Cooperative Extension Service publication HCM-04950. A 2,000 gallon tank with a two pipe system to prevent service interruption is the typical domestic size recommended. Larger is better, of course.

The cost of purchasing and installing a holding tank is about $3,250. This includes plumbing to the house. This initial cost is relatively small compared to the cost of purchasing water over a period of years. Delivered water is currently about 6 cents per gallon. The average home with a holding tank uses 1,500 to 2,000 gallons per month. If 2,000 gallons are used each month, this will cost $1,440 per year. The present value of the installation and operating costs over a three-year period and with a 9 percent discount rate is $6895. Over 20 years, the cost is $16,395. If only 1,500 gallons per month are used, these costs are $5,980 and $13,100, respectively.

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Map 1. Study Area Map, Well Locations and Roads
scale = 1:107,980

Gilmore Dome

Goldstream Road

Steese Hwy.

Chena Hot Springs Road

McGrath Rd.

Murphy Dome

Ballaine Road

Farmers Loop

Sheep Creek Rd.

Ester Dome

Ester Dome Rd.

Nenana Rd.

Chena Ridge

When we compare wells with holding tanks, we compare the cost incurred over several years. Since a dollar today is worth more than a dollar a year from now, it is inappropriate to simply sum the expenditures incurred over a number of years. To account for the timing of the expenditures, they are discounted to the present year value using the formula:

$$\text{Present Value} = \text{Cost}_t * (1+r)^t$$

In the formula, t is the number of years from now the cost is incurred, and r is the discount rate, or the interest rate, at which funds can be invested.

These costs assume that the cost of the delivered price of water does not change. Over a 20-year period and with a 9 percent discount rate, the cost of water from a holding tank drops from $16,400 to $14,200 if the price of water decreases from 6 cents to 5 cents per gallon.

WELLS

Unlike holding tanks, the cost of obtaining water from a well varies substantially depending on the well's location. The amount of arsenic, expected well depth, and yield for wells in the Fairbanks area are shown in Maps 2, 3 and 4. A change in any of these variables has implications for the total cost of the well.

The cost of drilling a well is usually the most significant part of the total costs. In 1998, drillers charged $32 per foot in the Fairbanks area. The depth to the water table can vary from under 100 feet to over 600 feet. Deeper wells also require larger and more expensive pumps. A quality pump presently costs from $665 for a shallow well to over $1,100 for a deep well.

ARSENIC

In the Fairbanks area, arsenic is an important geo-chemical constituent affecting groundwater quality. Water-well users in this area must deal with the occasionally-high occurrence of dissolved arsenic in the groundwater, in many cases exceeding the United States Environmental Protection Agency (EPA) water quality standards for human consumption set at 10 micrograms per liter (Jan. 2006 EPA.) In a 1-1/3 square mile area near the town of Ester, 28 of 40 wells had concentrations in excess of the maximum limit set by EPA. Map 2 shows arsenic concentrations in the study area.

Note that Map 2 indicates high arsenic concentrations in the Ester Dome and Goldstream Valley areas, but estimating the actual concentration is difficult because this area has very few wells. The indicated concentrations represent the influence of data values to the southeast and northwest, and centers in Goldstream Valley. There are also a series of small areas of high arsenic concentrations at the highest elevation of the Farmer's Loop area, which extends into the Gilmore Dome area. These areas correspond to areas of moderate lode mineralization. There is also an area of high arsenic in the upper reaches of the Steele Creek drainage in the Gilmore Dome area. Zones of low arsenic include most of Chena Ridge, higher elevations of Murphy Dome, most of the Gilmore Dome area and the lower elevations on the south slope adjacent to Farmer's Loop Road.

Arsenic is toxic to humans and can cause acute poisoning when ingested in high concentrations. In some instances, chronic ingestion of arsenic has been linked to cancer. The occurrence of arsenic in well water creates an appreciable health risk. It is possible to treat water to remove most of the arsenic. The most common methods use distillation, reverse osmosis or activated alumina. (See Table 1 State of Alaska Maximum Contaminant Levels (MCLs).)

The distillation and reverse osmosis systems are the least expensive, costing initially $500 and $1,000, respectively. Operating costs are less than $100 per year. Their major drawback is that they can only produce a limited supply of clean water. The activated alumina system costs about $1,000 initially and requires an annual expenditure of $300 to $400 for filters. This system can provide a constant supply of clean water. In this study, we use the cost of an activated alumina system when there is an arsenic level of over 10 parts per billion. This system provides a supply of water that is comparable in purity and convenience to water from a holding tank.
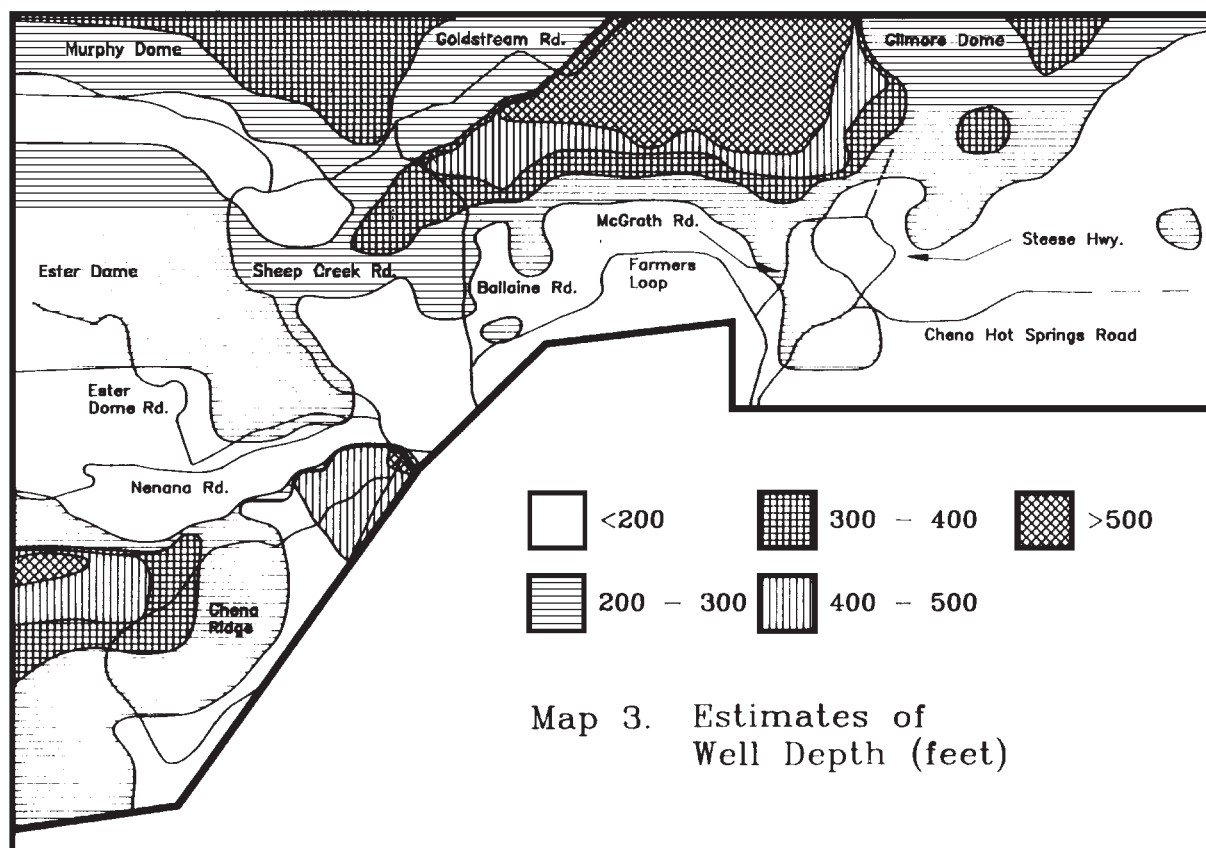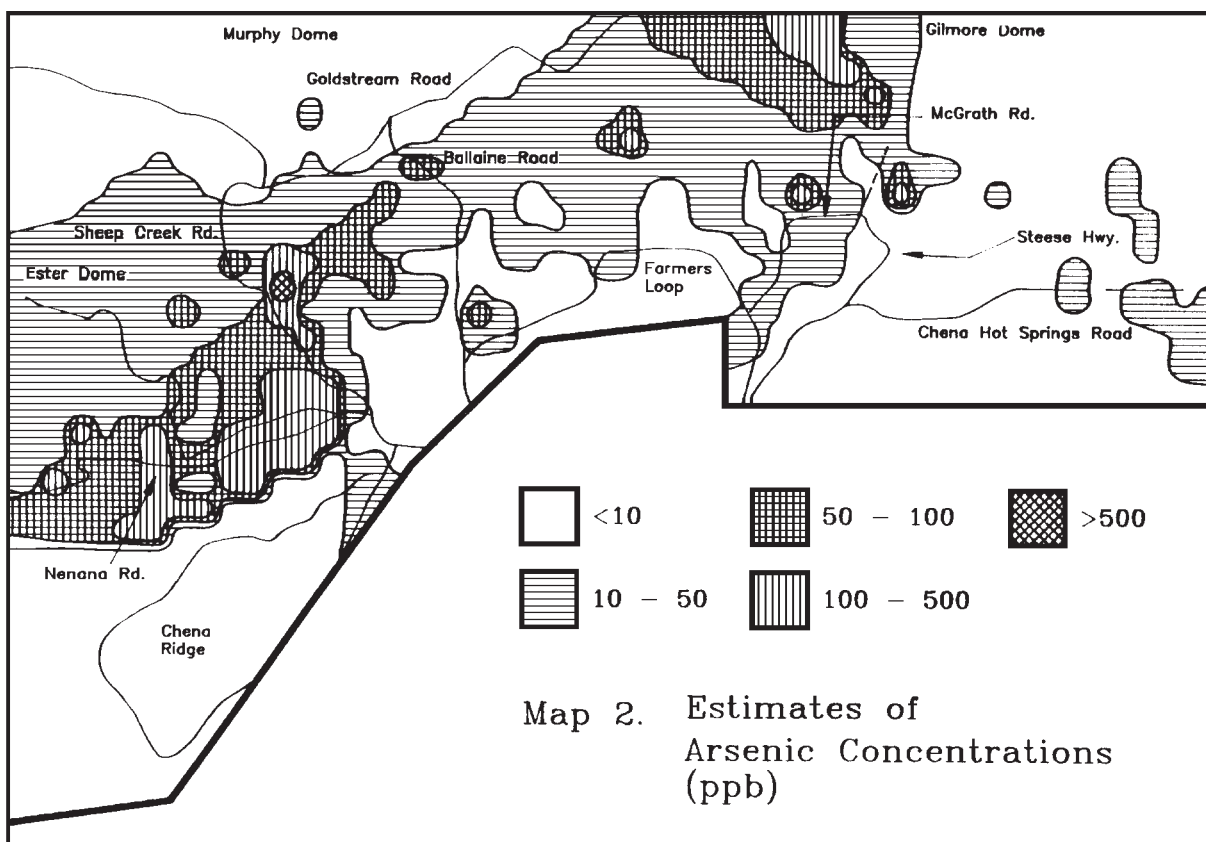
Map 2. Estimates of Arsenic Concentrations (ppb)

Legend:
<10
10 — 50
50 — 100
100 — 500
>500

Map 3. Estimates of Well Depth (feet)

Legend:
<200
200 — 300
300 — 400
400 — 500
>500

Table 1. State of Alaska Maximum Contaminant Levels (MCLs)

Inorganic Chemical Contaminants

Contaminant	Maximum Contaminant Level (mg/l)
Antimony	0.006
Arsenic	0.01
Asbestos	7 Million Fibers/liter (longer than 10 mm)
Barium	2
Beryllium	0.004
Cadmium	0.005
Chromium	0.1
Cyanide (as free cyanide)	0.2
Fluoride	4.0
Iron	0.3
Manganese	0.05
Mercury	0.002
Nickel	0.1
Nitrate	10 (as Nitrogen)
Nitrite	1 (as Nitrogen)
Total Nitrate and Nitrite	10 (as Nitrogen)
Selenium	0.05
Thallium	0.002

WELL DEPTH AND YIELD

Map 3 is the estimate for well depth, a factor which most directly relates to the cost of the well. Contour intervals are 100 feet. The southern section of the Murphy Dome, Gilmore Dome, Ester Dome and Farmer's Loop areas all show shallow well depths of less than 200 feet. These occur along valley bottoms and may result from the associated aquifers. Chena Ridge shows uniformly high well depths, but a strange trend. Progressively deeper wells occur at lower elevations at the east and west on the flanks of the ridge. Ester Dome shows no discernible pattern of well depth. The crest of the Farmer's Loop and Gilmore Dome areas west of Steele Creek show very great well depths of 300 to 500 feet. This trend expands into the Goldstream Valley to the north, but the accuracy of the trend is uncertain since very few wells have been drilled in that area.

Well drillers typically strive to obtain a flow of at least 10 gallons per minute. Some locations in the Fairbanks area will not provide this rate at any depth.

When the flow of water is less than 3 gallons per minute, it may be necessary to install a small water storage tank to allow an uninterrupted water supply. Such holding tanks cost between $735 and $1,000.
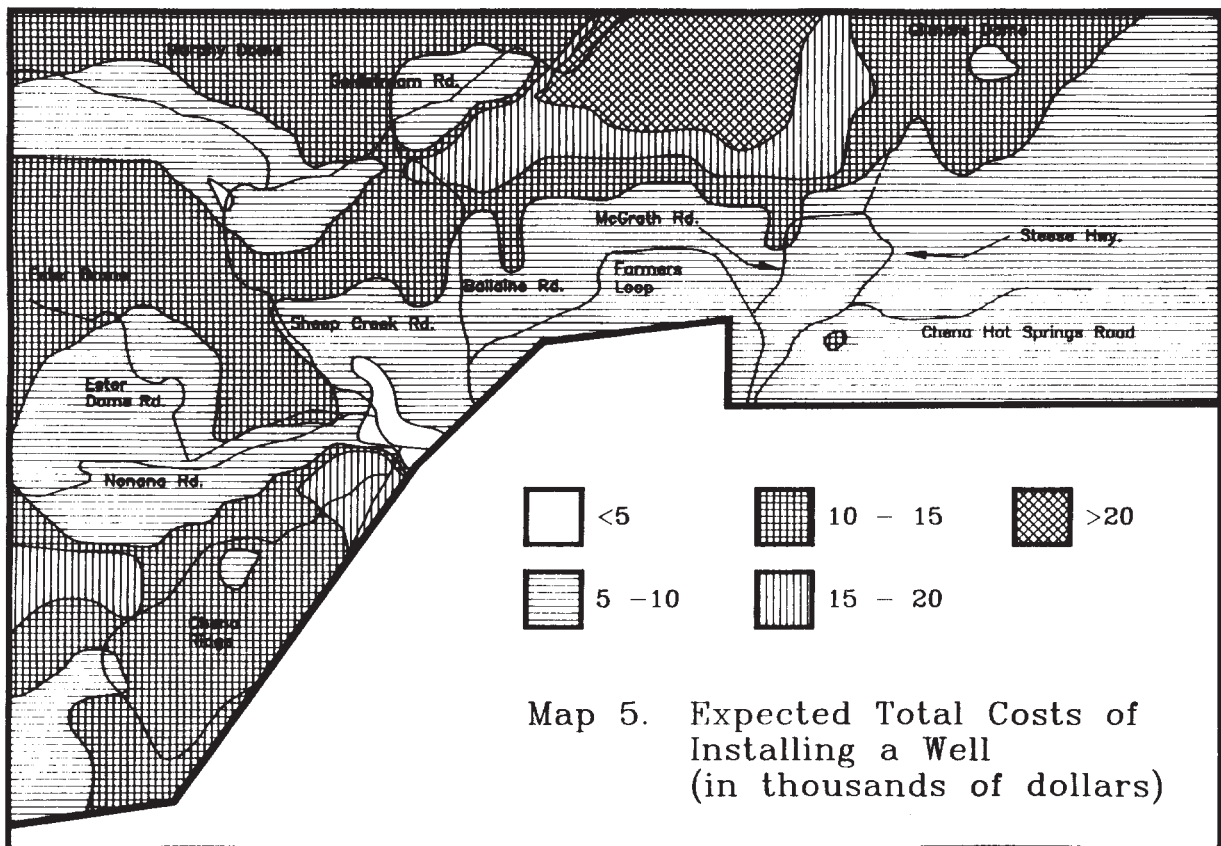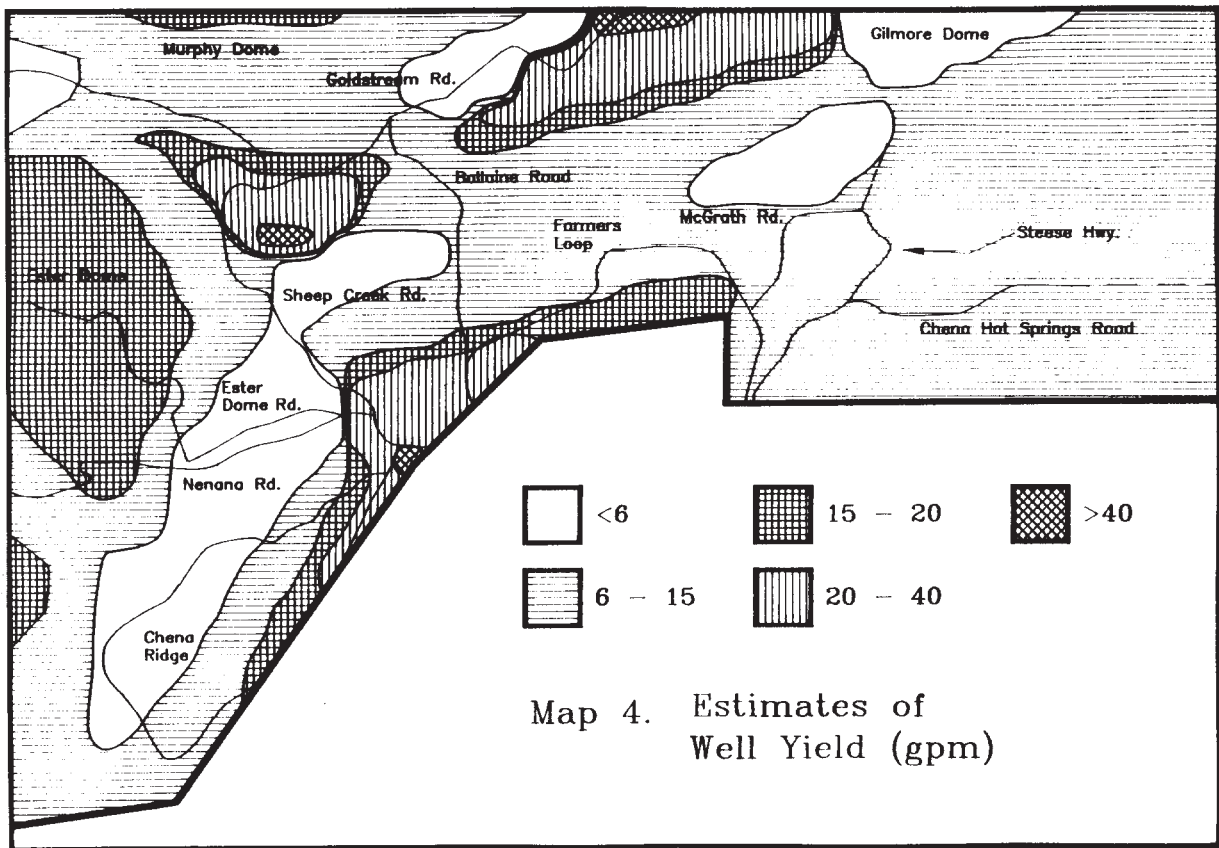
Costs that will be incurred with any well include plumbing from the pump to the house. This is usually $1,000 to $1,200. Operating costs include the cost of electricity which usually varies from $120 to $250 per year, depending on the well depth. A long-term cost is the replacement of the pump. Pumps will last an average of 15 years. When they fail, they must be replaced with a labor cost of about $300.

Map 4 is the general estimate map for well yield. Yields higher than 15 gallons per minute (gpm) are found along the Chena and Tanana rivers, along much of Goldstream Creek and over the higher elevations of Ester Dome. These are considered high yields in the local aquifers. In the Chena Ridge, Murphy Dome, Farmer's Loop and Gilmore Dome sub-areas, a trend exists — high elevations generally result in low yielding wells. Ester Dome is an exception in this trend with high yields at higher altitudes and very low yields along Ester Creek.

The highest risk area for well yield is Chena Ridge. Over most of the elevations above 750 feet on Chena ridge, there is a 90 percent chance of getting a well yield less than 10 gpm regardless of the depth of the well.

Using these dollar costs associated with the water quality, well depth and well yields shown in Maps 2, 3 and 4, a similar map was developed showing the expected cost of drilling and operating a well in the Fairbanks area. Map 5 shows the present value of the expected cost over 20 years given a 9 percent discount rate. This map combines the first three maps into one that can be used to find the expected cost of drilling and maintaining a well in any location in the study area shown in Map 1.

Map 5 shows the most likely cost of a well. However, for any particular location on this map, the actual cost could be quite different than that shown. Fortunately, the method used to develop these maps provides a measure of the accuracy of the expected costs. Using this information, Map 6 was developed. In Map 6, 95 times out of 100 we can expect to pay less for a well than the amount shown on the contour lines in Map 5. Note that this also means that 5 times out of 100, costs can be expected to exceed the amount shown on the contour lines.

Map 4.   Estimates of
Well Yield (gpm)

Legend:
- <6
- 6 – 15
- 15 – 20
- 20 – 40
- >40

Map 5.   Expected Total Costs of
Installing a Well
(in thousands of dollars)

Legend:
- <5
- 5 –10
- 10 – 15
- 15 – 20
- >20

COMPARISON OF WELLS AND HOLDING TANKS

It is instructive to look at Maps 5 and 6 in light of the expected costs of a holding tank. Over 20 years, the discounted costs of obtaining water from a holding tank will be about $16,395*. Where these maps show a well to cost less than the discounted costs of the holding tank, an optimal decision is to drill a well. Where the costs of drilling a well are higher than those of a holding tank, it may be best to use a holding tank. As of 1998, the best comparative decision contour to use in choosing between a well and a storage tank is the $15,000 to $20,000 contour on Map 6. Above this contour, a holding tank is a rational economic choice, based on a 16-year amortization of a well.

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*based on 9% discount (mortgage) rate. Actual history in the 1990s is a lower rate.

IMPORTANT VARIABLES NOT INCLUDED

So far, this report has concentrated on direct costs associated with wells and holding tanks. There are other factors that should be considered in deciding which to use. These require decisions on the part of the homebuilder.

This publication may be influential in financing a tank water system in place of a well. Regardless of the financing, the perceived cash flow required for a holding tank versus a well are different. A well requires a significant initial expense, while a holding tank costs relatively little at first, but is expensive to operate. The monthly cost of a well amortized over 16 to 20 years is buried in the typical homeowner's mortgage payment, which masks its magnitude. The cash flows are, in fact, not that different. The difference in cash flow between financing a well and buying delivered water over the term of a mortgage is more a difference in perceived cost than a difference in dollars actually spent for water.

The cash flow is quite different, however, if the home is being built gradually and largely out of pocket rather than depending on a traditional mortgage.

The initial cost of a holding tank is about the same as for a well drilled less than 80 feet. A look at Map 3 shows this is a rare occurrence. Therefore, a holding tank is the least expensive option over the short term of 3 to 5 years because of the high initial expenditure required to drill a well.

Related to these factors is the resale value of the house. It is difficult to determine the effect of a holding tank or well on the resale value. Appraisers have suggested that for houses costing $100,000 or less, a holding tank is an acceptable alternative to a well, and the resale value will not be effected. Above $100,000, homebuyers expect a well. A home in this price range with a holding tank will have a smaller pool of buyers, so it may sell for less or may take longer to sell.

Economic theory suggests that the value of undeveloped property in the Fairbanks area will reflect the expected cost of a well. Property in areas known to have shallow wells with good water will tend to sell for more than similar property with a high potential for a deep well or for high levels of arsenic. Where this is the case, the cost of a well is actually equalized among all locations. Appraisers have suggested that this may be the case.

Individual preference will have a major role in determining the water source for a home. Water from many wells in the Fairbanks area is high in iron, which can discolor clothes and hair. Water softeners add to the cost of a well, and can be inconvenient. Holding tanks have drawbacks, such as the potential for running out of water. Unlined tanks may rust, causing problems when the water is stirred up after the tank is refilled. For large families using several thousand gallons of water each month, a holding tank may not be a workable option.

CONCLUSIONS
(after Weber, 1986)

While subjective factors will play a role in the decision on a water source, the information presented here on the likely costs of a holding tank and a well is a vast improvement over asking a few neighbors for guidance. The information here allows a choice based on the most likely outcome, and also provides a quantified measure of the uncertainty of the outcome.

Based on the risks assessed here, some detailed conclusions can be drawn.

1. The southwest corner of the Gilmore Dome subarea may be the most optimal and lowest risk area to drill a well to obtain a potable, sufficient water supply.

Map 6. 95% Confidence Costs
(in thousands of dollars)

Legend:
- <10
- 10 – 15
- 15 – 20
- 20 – 25
- >25

Labels on map: Steese Hwy., Chena Hot Springs Road, McGrath Rd., Farmers Loop, Ballaine Rd., Goldstream Rd., Sheep Creek Rd., Ester Dome, Ester Dome Rd., Nenana Rd.

2. The Farmer's Loop, Murphy Dome and Gilmore Dome regions contain areas of arsenic enrichment, and have a tendency for lower well depths. The Chena Ridge area has a tendency for low arsenic content and deep wells.

3. Low-well yields dominate the Chena Ridge, Murphy Dome and Farmer's Loop sub-areas.

4. The occurrence of high arsenic values in the groundwater are coincident with areas of high lode and placer potential. The area between Ester Dome, Farmer's Loop Road and the lower end of Goldstream Valley show extremely high arsenic values not connected with any specific mineralization.

5. The spatial distribution of well yield, well depth and arsenic suggest that Farmer's Loop sub-area shows continuity with the northern section of the Gilmore Dome. This means that the two areas have similar well risks.

6. The occurrence of arsenic in both the Farmer's Loop and Ester Dome areas is high, but shows different associations with well yield and well depth. These differences are related to variations in the local geology.

7. Ester Dome shows characteristics that set it apart as a distinctive area. In particular, it has the highest arsenic concentrations, the shallowest wells and the highest yields.

8. Chena Ridge also shows characteristics that set it apart as a separate geohydrologic domain. Yields are low, and deeper wells tend to occur at lower altitudes.

9. The Birch Creek schist bedrock in the Gilmore Dome area represents a low-risk aquifer.

SOURCES:

A Stochastic Model and Risk Analysis of Arsenic, Well Depth, and Well Yield in the Fairbanks Area, Alaska. M.S. Thesis, 196 pp., Eric Freeland Weber. University of Alaska Fairbanks, 1986.

Suggestions for Installing Domestic Water Storage Tanks, HCM-04950, 4 pp., Richard D. Seifert. Cooperative Extension Service, University of Alaska Fairbanks, 1992.